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TECHNICAL MEMORANDUM

EPA TECHNICAL COMMENTS ON THE PRP PILOT LEACH TEST REPORT AND RELATED TECHNICAL ISSUES

Groundwater/Surface Water Operable Unit
Galena Subsite
Cherokee County Site
by CH2M HILL
September 18, 1989

PURPOSE

The purpose of this technical memorandum is to collect previously transmitted information on the recently completed PRP conducted pilot leach tests for the proposed remedy, provide technical comments on the content and interpretations contained in that report (Adrian Brown Consultants, August 18, 1989), and transmit related technical information regarding the mine wastes within the subsite. The technical memorandum addresses these issues in two main sections. The first covers the contents and analyses presented in the pilot test report. The second section covers the related technical issues

PRP REPORT

The PRP FINAL REPORT OF INVESTIGATIONS: PILOT LEACH TESTING, dated August 18, 1989, documents tests based on a jointly developed EPA and PRP work plan to evaluate what would happen if mine wastes were placed in the mine voids as envisioned by the remedy proposed in the Groundwater/Surface Water OUFS Supplement (July 1989) The test work was undertaken by the PRP technical consultant with oversight by CH2M HILL technical staff.

Two major questions were to be answered by the testing program:

1. Do the metals in the classified mine wastes (above two inch size waste rock and low zinc (less than approximately 5,000 ppm zinc) leach from the wastes if placed into acidic groundwater, and if so, at what rate?

2. Does a rainfall event cause metals to be leached at an increased rate from the wastes placed as defined above by changing the pH and Eh of the groundwater through natural infiltration?

The EPA approved work plan involved two simultaneous flow-through tests, one involving calcareous mine waste rock and the other, siliceous mine waste rock. Both tests included mixing the plus 2-inch mine wastes with low zinc (less than 5,000 ppm) chat. Both waste types were to be representative mixture of wastes at the subsite. Field measurements of both water quality and approximate water levels were to used to select the source of acidic groundwater to be used in the tests. The local source of acidic groundwater was to be put through the two mine waste-chat mixtures at a rate that approximates the current subsite groundwater velocity. Once it had been established that an equilibrium situation had been achieved using the groundwater (a minimum of approximately 4 to 6 pore volumes), a similated rainwater source of low total dissolved solids would be put through the tanks to simulate a rainfall diluting the naturally occurring groundwater. The rainfall event was to be continued until an equilibrium was again achieved. This was to be followed by a return to direct groundwater until an equilibrium was again achieved. Finally, the drops in water levels as the tanks were emptied were to be measured to determine the permeability of the mixed wastes.

Additionally, a series of batch tests were performed to supplement the flow-through data. This was extended to an initial batch test using the flow-through tanks in order to correlate the two methods of leaching the mine wastes. A batch test leach result depends on how long a given waste rock to source water ratio is in contact under such design conditions as major ion chemistry, temperature, pH, Eh, etc. The amount of metals released for any given material can vary depending on the rock to water ratio and all the other parameters (which need to be defined if a test is be considered valid and reproducible). In summary, the individual metals have solubility limits that are controlled by the above noted factors. The amount of metals released in a flow-through test depend on these parameters (batch solubility limits) but also include a kinetic factor (how fast are the metals released) that simulates the release of metals resulting from water flowing through the material. The flow-through tests are essentially large scale column tests under field conditions that approximate field scale emplacement of the wastes using local groundwater to leach the mine wastes.

The PRP report addresses the general intent of the field pilot tests and the batch tests, but contains both additions and deletions of specific parameters in the work plan.

With the respect to the flow-through tests, the results indicated that the emplaced selected wastes released an initial concentration of metals higher than the source concentrations. The tests to document the effect of rainfall on the leaching of the mine wastes met the intent of the work plan but not the intended duration. The results of the rainfall test indicate that the rainfall will not affect the leaching of metals under the conditions of the test. The tests were limited in both volume and water chemistry thus a potential new equilibrium point was not reached. The rainfall test involved only one pore volume of a simulated rainwater containing essentially the same total dissolved solids and pH as that of the source water. This part of the test can be considered as favorable to the extent that the infiltrating rainfall is at or near a total dissolved solids of approximately 300 milligrams per liter and has a pH of approximately 5.

The PRP interpretation of the batch and flow-through tests is, for the most part, a valid interpretation of the results. However, the interpretation of both tests is extended beyond the valid range of the test data. In the case of the flow-through tests, the impact of the initial release of the metals is ignored by using the phrase "long-term effect on the shallow groundwater." The initial release (one component of the batch tests) will increase the metals load to the groundwater in the mine workings which will then disperse this added metal load into both the surface and shallow groundwater. The PRPs did discuss this phenomenon in their comments on the proposed plan. Furthermore, the test results are valid for those groundwaters with a pH of 5 or higher in contact with mine wastes containing at least 3 percent carbonate. The extent of these conditions throughout the subsite has not been established.

Due to the short time available to conduct the pilot studies, no tests were conducted on mine shafts to determine what area of the subsite the tests are valid for and which are still undefined. The Blue Hole contains water at pH of approximately 3.5. Unfortunately, the batch tests for the mine wastes in Blue Hole water were inconclusive as the before concentrations for lead exceeded the after concentrations. Therefore, the flow-through test result interpretations do not apply to this groundwater. Jar leach tests performed last fall by the EPA showed that metals could be released from mine waste fines under similar conditions. Also, there is insufficient data to define how much carbonate is present in either the mine waste rock or the chat around the subsite. The carbonate levels in the wastes may become moot in the long term, however, because the mine workings will continue to generate an acid for an unknown but certainly long term (It has already done so for more than 60 years). Is there enough carbonate in the selectively placed mine wastes to keep the pH equal to or higher than 5?

The test results cannot be extended without qualification to the site-wide groundwater conditions without additional classification of both the groundwater chemistry and the surface mine waste chemistry through other portions of the subsite.

The flow-through test results indicate that, following an initial release of metals, the groundwater will return to ambient metals concentrations within a few pore volumes. Therefore, placement of the mine wastes selectively as outlined in the OUFS Supplement into the holes was accepted as the appropriate remedial action with stipulations to match placement to the conditions of the test results to the extent feasible. The amount of mine waste to be placed into the shallow groundwater system can be managed through the use of dry holes and volume above the water table. The pilot test results, if valid across the subsite, indicate that the assumptions used to prepare the mass loading model for Appendix E of the OUFS Supplement are conservative, and that the reductions in loadings projected by the model are lower than would be expected long term with the selective placement remedy component.

The PRP interpretation of the batch test results is that eliminating the smaller than 2-inch material from the mine wastes would and should not be necessary. A comparison of the batch tests 1 and 2 (less than 2-inch removed) with tests 3 and 4 (unscreened mine waste) in the report indicate that screening to remove the finer-grained mine waste (nominally less than 2-inch) is necessary to reduce the lead and cadmium load. The EPA jar tests indicated this leaching characteristic of the finer mine waste rock materials when they were performed last fall. The additional contention that the screening will abrade or break the mine wastes exposing new fresh mineral faces to be leached is not substantiated by the field tests.

ASSOCIATED ISSUES

CADMIUM-ZINC LINKAGE

Most of the cadmium, unlike lead, is not present in minerals of its own but is tied up in zinc minerals and compounds. Therefore, the concentration of dissolved cadmium and zinc are linked in a common source. Once the action level for cadmium is established, an action level is automatically set for zinc (and vice versa) within approximately a 20 percent variation in the exposed minerals. A cadmium action level of 25 ppm equates to a zinc concentration of approximately 5,000 ppm.

A level of concern has been established for zinc concentrations contained in the mine waste chat due to its potential adverse effects to area aquatic biota, its link to the cadmium concentration, and zinc's tendency to leach (along with the cadmium) from the mine waste and migrate in both the groundwater and surface water systems. The linked concentration of zinc with cadmium in chat will therefore dictate what chat is potentially placed both on the surface and below the water table. Based on the results of the pilot leach tests, chat can be placed as described below.

1. Chat containing zinc above 10,000 milligrams per kilogram (mg/kg equal to ppm) could be placed in dry mine voids (above the water table) and covered with material containing less than 25 ppm cadmium to control the exposure and release of both cadmium and zinc.

2. Chat containing zinc between 5,000 and 10,000 ppm could be placed either in dry mine voids or voids containing groundwater with a pH greater than 5. The pilot test data indicate that a pH of 5 or greater restricted the release of both zinc and cadmium.

3. Chat containing less than 5,000 ppm zinc, and therefore less than 25 ppm cadmium, could be placed in any of the available mine voids (above or below the shallow groundwater table) or on the surface.

MODELING OF LEAD MIGRATION IN THE NATURAL WATER SYSTEMS

The lead concentration is not modeled in the Operable Unit Feasibility Study or specified in the above conditions because of lead's specific chemical characteristics and it's mode of occurrence in the mine wastes. Lead was the primary, and for the most part the only, metal recovered during the mining activity at the subsite. Therefore, the mine wastes contain a lower proportion of lead than zinc (which for the most part was not recovered and contains most of the cadmium). However, the proportion of the lead remaining (source of leachable lead) is mostly in the finer-grained mine wastes as a variable mixture of sulfates, carbonates and oxides as well as adsorbed onto the iron oxyhydroxide minerals. Therefore, by screening the finer-grained material (nominally the less than 2 inch material) from the mine waste, most of the soluble lead is isolated into a smaller volume of material.

Furthermore, at a pH of approximately 5 or higher, lead is adsorbed by the iron oxyhydroxides, whereas zinc and cadmium require a pH of approximately 7 or higher. Therefore, a groundwater with a pH of 5 but preferably higher, coupled with the limited solubility of lead sulfite and carbonate, could effectively control the concentration of lead in the groundwater where there is abundant iron oxyhydroxide (as there is in the mine wastes). Also, since the carbonate is soluble in water only at a pH of approximately 4.5 or higher, a pH of 5 or higher is desired to limit the solubility of lead. Below a pH of approximately 4.5, the carbonate is mostly converted to carbon dioxide gas and not available to precipitate lead as a lead carbonate.

XRF MEASUREMENTS ON CHAT

In conjunction with the mine waste classification activities performed in conjunction with the pilot testing program, a study was made with the field portable XRF for the lead content of a major chat pile near Galena in the Hells Half Acre area (EPA Zone 7).

Table 1 presents the results of the XRF measurements on bulk samples from this pile. These measurements were made on the afternoon of June 1, 1989. Two circles of measurements were made around the pile.

XRF measurements indicate an average lead concentration of 1,040 milligrams per kilogram (mg/kg equals parts per million) on a bulk basis. This average was calculated from 11 measurements at random spots around the chat pile. The observed lead concentrations ranged from approximately 70 to 1,970 mg/kg. XRF measurements have a tendency to measure more of the fine-grained material than the coarse-grained material, therefore these numbers should be considered semiquantitative only. A composite sample was prepared from the 11 locations. This composite sample lead concentration was measured three times. The average of these three readings was 1,080 mg/kg which is approximately the same lead concentration as the average for the 11 spot samples. Zinc concentrations are also reported for each of the lead measurements.

Table 1
CORNWALL/JOPLIN ROAD DISTRICT CHAT PILE
Zone 7, Galena Subsite, Cherokee County, Kansas

	INDEX NUMBERS		CALCULATED CONCENTRATIONS	
	Lead	Zinc	Lead (mg/kg)	Zinc (mg/kg)
1	0.90	2.13	1,080	13,300
2	1.11	2.66	1,890	17,100
3	.71	.91	340	4,570
4	.99	2.07	1,430	12,900
5	.78	.46	610	1,350
6	.92	.52	1,270	1,780
7	1.13	.44	1,970	1,210
8	.92	.50	1,150	1,640
9	.64	.37	70	710
10	.86	1.45	920	8,430
11	.77	1.70	570	10,200
Ave	.89	1.20	1,040	6,640

	----------------XRF----------				LAB DETERMINATIONS	
Std	Index Nos.		Lead	Zinc	Lead	Zinc
1	1.28	1.37	2,550	7,860	2,700	8,350
1	1.27	1.37	2,510	7,860	"	"
1	1.33	1.49	2,750	8,720	"	"
2	.93	.30	1,190	210	1,350	340
2	.96	.39	1,310	850	"	"
3	.87	.42	960	1,060	1,050	850
4	.77	.79	570	3,710	610	4,000
5	.77	1.16	570	6,360	770	6,060
6	1.32	1.49	2,710	8,720	2,200	7,740
7	.74	1.06	460	5,640	450	6,600

Composite Sample

	.80	1.24	690	6,930
	.96	2.05	1,310	12,700
	.94	.76	1,230	3,500
Ave			1,080	7,710

Statistics- Least Square Fit Analysis

	Lead	Zinc
Correlation Coefficient	0.98	0.99
Intercept (a)	0.6226	1,937.5
Slope (b)	.2353	7149.9